CLAIMS

WHAT IS CLAIMED IS:

1. A method of achieving symbol synchronization, the method comprising:

receiving a pilot signal having at least two phase states, wherein the pilot signal transitions between phase states only on a symbol boundary, and wherein the transitions occur not more than once for every two symbols;

measuring the pilot signal as a sequence of measured symbols;

calculating a phase difference between adjacent measured symbols; and

upon detecting a phase difference greater than a predetermined threshold:

determining a coarse alignment offset; and

applying the coarse alignment offset to align a boundary between measured symbols with a pilot signal transition.

2. The method of claim 1, further comprising:

training a time domain equalizer after applying the course alignment offset;

determining a fine alignment offset after training the time domain equalizer; and

applying the fine alignment offset to more accurately align boundaries between measured symbols with boundaries between received symbols.

3. The method of claim 1, wherein said determining a coarse alignment offset comprises:

forming a data field from two adjacent measured symbols having a phase difference greater than the predetermined threshold, a measured symbol immediately preceding said two adjacent measured symbols, and a measured symbol immediately following said two adjacent measured symbols;

searching for the position of a two-symbol window in the data field that maximizes a phase difference; and

calculating an offset from said position.

4. The method of claim 3, wherein said searching for a position comprises:

systematically indexing through a range of window positions; and

at each position, measuring a phase difference between two symbols defined by the window.

5. The method of claim 3, wherein said searching for a position comprises:

indexing through a range of window positions at a coarse increment to determine a first position at which the phase difference is maximized; and

indexing at a fine increment through a reduced range of window positions surrounding the first position to determine a second position at which the phase difference is maximized.

6. The method of claim 1, further comprising:

acquiring a sample clock from a second, unmodulated pilot signal received concurrently with the first pilot signal.

7. The method of claim 1, wherein a first of the two pilot phase states is indicative of a symbol sent during a period of near-end cross-talk (NEXT) from a time-compression multiplexing integrated services digital network (TCM-ISDN) communication on another channel, wherein a second of the two pilot phase states is indicative of a symbol sent during a period of far-end cross-talk (FEXT) from the TCM-ISDN communication, and wherein the first and second of the two pilot phase states are separated by 90°.

8. The method of claim 7, wherein the predetermined threshold is 22.5°.

9. The method of claim 1, wherein said calculating a phase difference comprises:

calculating for each symbol a Fourier transform coefficient associated with a pilot signal frequency;

determining a phase angle from each said Fourier transform coefficient; and

finding a difference between the phase angles.

10. A modem that comprises:

a processor adapted to couple to a channel to receive symbols, wherein the channel experiences alternate intervals of near-end cross talk (NEXT) and far-end cross talk (FEXT), and wherein during an initialization sequence, symbols received from the channel include a pilot tone having phase states indicative of symbols sent during FEXT intervals ("FEXT symbols") and symbols sent during NEXT intervals ("NEXT symbols"); and

a memory coupled to the processor and configured to store executable instructions, wherein the executable instructions configure the processor to:

measure a sequence of symbols;

calculate phase differences between adjacent symbols; and

determine an offset for symbol alignment after detecting a phase difference greater than a predetermined threshold.

11. The modem of claim 10, wherein as part of determining the offset, the executable instructions configure the processor to:

establish a data field from two adjacent symbols having a phase difference greater than the predetermined threshold, an immediately preceding symbol, and an immediately following symbol;

search for a two-symbol window position in the data field that maximizes a phase difference; and

calculate an offset from said window position.

12. The modem of claim 11, wherein as part of searching for a two-symbol window position, the executable instructions configure the processor to:

systematically index through a range of window positions; and

measure at each position a phase difference between two symbols defined by the window.

13. The modem of claim 11, wherein as part of searching for a two-symbol window position, the executable instructions configure the processor to:

index through a range of window positions using a large increment to determine a first position at which the phase difference is maximized; and

index through a reduced range of window positions around the first position using a small increment to determine a second position at which the phase difference is maximized.

14. The modem of claim 10, wherein as part of calculating phase differences, the executable instructions configure the processor to:

calculate for each symbol a Fourier transform coefficient associated with the pilot tone;

determine a phase angle from each said Fourier transform coefficient; and

find a difference between the phase angles.

15. The modem of claim 10, wherein the predetermined threshold is about 22.5°.

16. An ADSL communications system that comprises:

a central office transceiver configured to transmit during an initialization phase a sequence of symbols carrying a pilot signal, said pilot signal being modulated to indicate at least two symbol types; and

a remote transceiver coupled to the central office transceiver by a communications channel, wherein the remote transceiver is configured to measure a sequence of unsynchronized symbols, and is further configured to determine an offset between an unsynchronized symbol boundary and a pilot signal transition.

17. The system of claim 16, to determine said offset the remote transceiver is configured to measure pilot signal changes between adjacent unsynchronized symbols, and after identifying two adjacent symbols having a pilot signal change that exceeds a predetermined threshold, the remote transceiver is configured to search, within a larger region containing the identified symbols, for a two-symbol window position that maximizes a pilot signal change between the two symbols defined by the window.

18. The system of claim 17, wherein the remote transceiver is configured to search for the two-symbol window position by systematically indexing through multiple window positions within the larger region.

19. The system of claim 17, wherein the remote transceiver is configured to search for the two-symbol window position in at least two stages, wherein in a first stage the remote transceiver indexes through multiple window positions in the larger region using a large increment, and wherein in a subsequent stage the remote transceiver indexes through multiple window positions in a reduced region using a small increment.

20. The mode of claim 17, wherein the at least two symbol types include FEXT symbols and NEXT symbols, wherein the pilot signal is modulated at +45° to indicate FEXT symbols and -45° to indicate NEXT symbols, and wherein the predetermined threshold is about 22.5°.